Long-Term Effects of Increasing Ethanol Production on Agricultural Markets, Trade, Land Use, and Food Insecurity

Economics of Alternative Energy Sources and Globalization: The Road Ahead
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Objectives

• Project the long-run effects of a mandated 5 billion gallon per year increase in ethanol production on
  – Ag prices and production
  – Land Use
  – Worldwide food insecurity

• Consider the influence that significantly reduced cost of enzymatic hydrolysis would have on these effects
Approach

• First stage: project general equilibrium effects with CGE model

• Second stage: Use UN-FAO methodology to project the effects of changing consumption bundles on numbers of food insecure people
CGE Model

- 9 world regions, 35 production sectors
- GTAP 6 data
- New sectors:
  - Switchgrass
  - Stover (produced jointly with coarse grain)
  - Grain ethanol
  - Switchgrass ethanol
  - Stover ethanol
UN-FAO Hunger Method

• Basic idea:
  – Using survey data, estimate distributions of caloric intake in each region
  – Shift mean of distribution, see how proportion of the population below a minimum hunger cutoff changes

• Lognormal distribution assumed

• According to FAO, the shapes of these distributions are quite stable
UN-FAO Method
FAO Method (con.t)

- $r_l$ is based on composition of population
- We use FAO's 2001 food balance sheets
- We use simulation to estimate caloric intake distributions for the 9 aggregate regions in the CGE
- We map the UN food categories to the food commodities in the CGE
Scenarios

• 1) Full cost enzymatic hydrolysis of biomass
• 2) 55% reduction in enzyme costs
• Ethanol increases from 10 bgy to 15 bgy in both scenarios
Ethanol Production

- Expensive Enzyme Scenario
- Cheap Enzyme Scenario

- Stover Ethanol
- Grain Ethanol
Production of Ag Commodities

- Expensive Enzyme Scenario
- Cheap Enzyme Scenario
<table>
<thead>
<tr>
<th>Region</th>
<th>Expensive Enzymes</th>
<th>Cheap Enzymes</th>
</tr>
</thead>
<tbody>
<tr>
<td>USA</td>
<td>-7.12</td>
<td>-3.88</td>
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<tr>
<td>Brazil</td>
<td>0.13</td>
<td>0.15</td>
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<tr>
<td>China</td>
<td>-0.75</td>
<td>-0.69</td>
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<tr>
<td>India</td>
<td>-0.04</td>
<td>-0.02</td>
</tr>
<tr>
<td>Other Far East</td>
<td>-1.00</td>
<td>-0.43</td>
</tr>
<tr>
<td>Western Europe</td>
<td>-0.35</td>
<td>-0.24</td>
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<tr>
<td>Eastern Europe and FSU</td>
<td>0.02</td>
<td>0.02</td>
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<tr>
<td>Central and South America</td>
<td>-1.05</td>
<td>-0.42</td>
</tr>
<tr>
<td>Rest of the World</td>
<td>-0.74</td>
<td>-0.57</td>
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Changes in Percent Hungry
Full Cost Enzyme Scenario
Changes in Percent Hungry
Reduced Cost Enzyme Scenario
<table>
<thead>
<tr>
<th>Region</th>
<th>Expensive Enzymes</th>
<th>Cheap Enzymes</th>
</tr>
</thead>
<tbody>
<tr>
<td>USA</td>
<td>0.023</td>
<td>0.009</td>
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<tr>
<td>Brazil</td>
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<td>China</td>
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<tr>
<td>India</td>
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<tr>
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<td>0.070</td>
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<tr>
<td>Western Europe</td>
<td>0.006</td>
<td>0.000</td>
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<tr>
<td>Eastern Europe and FSU</td>
<td>-0.006</td>
<td>-0.006</td>
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<tr>
<td>Central and South America</td>
<td>0.122</td>
<td>0.037</td>
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<td>Rest of the World</td>
<td>0.514</td>
<td>0.391</td>
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<tr>
<td><strong>Total</strong></td>
<td><strong>1.182</strong></td>
<td><strong>0.786</strong></td>
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</tbody>
</table>
Caveats

• Long-term equilibria
• Increases in grain productivity
• Increases in ethanol production may be much larger
• Using 2001 population data
• Non-US biofuel production increases
Conclusions

- Moderate increases in US ethanol production will result in modest long-run changes in the agricultural economy and food security
- Cellulosic ethanol production fueled by corn stover
- Increased hunger most painful in the Africa, the Far East and S. America (excluding Brazil)